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P. O. Van Keuren
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22. ABSTRACT (Continue on reverse side if necessary and identify by block number) THE OBJECTIVE OF THIS REPORT IS TO PROVIDE DATA FOR THE SUBSTANTIATION OF MIL-G-81322 GREASE IN LIEU OF SAE 10W-30 OIL AS THE LUBRICANT FOR THE GRIP AND TRUNNION IN THE OH-58A MAIN ROTOR HUB ASSEMBLY.		

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FINAL REPORT
P.I.P. TASK 72-7 GREASE LUBRICATED
MAIN ROTOR HUB

PROGRAM OBJECTIVE

Develop a Main Rotor Hub Assembly capable of using MIL-G-81322 grease in lieu of SAE 10W-30 Oil. This testing and development would apply only to the lubrication of the bearings in the Main Rotor Grip.

BACKGROUND

Numerous reports from the field advised of oil leakage at in-board grip seals of the main rotor. The condition was common to both the OH-58A and JetRanger Helicopters. The problem was not serious, however considerable maintenance time was expended servicing the oil reservoirs to replace depleted oil and cleaning oil from surrounding controls. Continued operation of the helicopter, when this condition exists, can result in a hazardous condition. This introduces additional maintenance hours to replace the leaking seal. Replacement parts and manhours associated with this maintenance can be eliminated.

TEST PROGRAM PHASE I

Layout Drawing 206-018-035 was created and details fabricated to modify the 206-011-100-5 Hub Assembly from OH-58A BHT S/N 42126. The modified hub assembly was installed on the aircraft to obtain a qualitative investigation under normal ambient temperature, ground operation and flying conditions.

After ground running for 30 minutes at flat pitch, the helicopter was tied down for a series of ground runs applying collective pitch. During each ground run the load was varied several times by changing the collective pitch position. The maximum power was determined by the turbine outlet temperature (TOT) limits. The ground runs were first conducted in one-hour blocks and later in two-hour blocks. During the test the cyclic control stick was held in a forward position (70 percent). The controls were cycled every two minutes. After each ground run the hub was inspected for leakage and temperature increase in the area of the feathering bearings. A total of 20 hours was accumulated during the ground run tests.

All flight testing was conducted at 3000 pounds gross weight and a mid center of gravity, Fuselage Station 109.4. Basically, the

flight testing was conducted in blocks of 1.5 hours. The profile flown in each block practically covered all maneuvers made during normal operations. A review of the flight conditions is given in Appendix Page A-1. A total of six flight hours were accumulated.

RESULTS AND DISCUSSION

After the main rotor hub was modified to accept MIL-G-81322 grease as a lubricant, the main rotor hub and blade assembly was balanced and the hub assembly purged. During this initial purging the double lip seal, P/N 476332, prevented the grease from reaching the cover ring. Leakage of the grease from under the shield was considered as criteria that grease reached all parts of the hub. This did not occur. To provide adequate main rotor hub purging, the outboard lip of the double lip seal was removed.

At the start of the ground tests grease was added twice to the hub assembly, each time after ground running for two minutes at flat pitch. Grease was also added after 4.8 hours of ground run and 4.0 hours of flight.

It was observed that after each ground run and flight the grease leakage around the cover ring not associated with purging was either minimum or non-existing. Observation of the hub after each engine shutdown indicated no temperature increase.

Upon disassembly of the hub it was discovered that the inner hub bearings were insufficiently lubricated to provide a long service life. Evidently, the grease leakage during the purging process was not a true indication that the grease was reaching the hub bearings in sufficient quantity.

It was then decided that continuation of the test program, which called for a total of ten flight hours, was not warranted. Subsequently, the rotor hub was cleaned and reassembled using SAE 10W-30 as a lubricant.

Prior to conducting the proposed Phase II Test of the task an evaluation of various lubricants was conducted in the BHT Engineering Laboratory. Some commercial operators had been using 50 weight oil in the main rotor hub assembly as a means of controlling leaking hub assemblies. Operators using 50 weight oil had reported the following problems at minus thirty (30) to thirty-five (35) degrees fahrenheit:

High vibration levels, blades popping out of track in flight, and observation of pitch links bowing during ground run. Lab Tests

were performed at 0°F, -25°F, -45°F, and -65°F using SAE 10W-30 Oil, 50 Weight Oil and MIL-G-81322 Grease. One (1) grip of the hub assembly remained empty to provide baseline data for lubricant comparison. The stiffening effect of low temperature on the urethane tension strap, P/N 206-010-105-3, could also be observed. Open containers of each lubricant were placed in the environmental chamber during the test of the particular lubricant in the grip cavity of the hub assembly. The "break away" force required to rotate grips was measured by a spring scale at the pitch horn. A review of the test data is given in Appendix Page A-2 and Page A-3.

RESULTS OF LOW TEMPERATURE LUBRICATION TEST

10W-30 Oil does not freeze at low temperatures. At -65°F only six (6) additional pounds of "break away" force is required to move the grip with oil vs. the empty or baseline grip. MIL-G-81322 Grease required the same force as SAE 10W-30 Oil at -25°F, at -65°F MIL-G-81322 required ten (10) pounds more force. After cycling the grip the force dropped to seven (7) pounds. The difference between SAE 10W-30 and MIL-G-81322 will not affect the loads on the OH-58A rotating controls. 50 Weight Oil was slightly higher than 10W-30 at -25°F. At -65°F it was frozen solid and could not be moved. The critical point is -30°F to -35°F which agrees with previous reports from commercial operators.

The results prompted the contractor to advise the customer to terminate any effort on the proposed Phase II Test and await the results of testing by commercial operators. The flight time accumulated by commercial operators would provide the opportunity to inspect a sufficient number of main rotor hub assemblies at the 1200 hour overhaul interval which used MIL-G-81322 Grease. The customer concurred with the recommendation and the program was held in abeyance pending the results of independent testing conducted by BHT Engineering, Service Department, and Commercial Operators.

COMMERCIAL TESTING

In 1973 BHT Engineering and Service Department started limited testing of MIL-G-81322 Grease as the lubricant in the 206A & B Main Rotor Hub Assemblies. Four commercial operators flying in Canadian and Arctic Winter conditions agreed to provide the test helicopters. BHT field service representatives assisted the operators in modifying the four (4) hub assemblies to use MIL-G-81322 grease in lieu of SAE 10W-30 oil. The modification was accomplished by the following procedure:

1. Remove the grips and pitch horns from the main rotor. Thoroughly clean the grips and bearings per M&O Instructions.

2. Journal wear is of prime importance - dimensionally check the four bearing journals of the main rotor yoke.
3. Hand pack the bearings with grease, install in grips and coat the grip I.D.'s approximately 1/4 inch deep with grease.
4. Replace the pitch horn seals. Install the double lip seal facing inboard with the metal case outboard. Trim the outboard seal lips flush so that excess grease may escape when additional grease is injected into the grips.
5. Drain and flush the oil reservoirs that are secured to the pitch horns. Remove the vents and replace with grease zerks. Remove sight glasses from reservoirs, and fabricate washers to the same I.D. and O.D. of the sight glass using 2024T3 aluminum, .250 thick. Install washers in lieu of sight glasses.
6. Install pitch horns on the yoke. Liberally coat the spindles with grease. Fill the recess between the spindle bearing journals with grease. Reassemble the grips to the hub.
7. Inject grease through the zerks until it escapes past the inboard seals. After ground run again inject grease as required to assure that all air is purged from the grips.
8. The grips must be kept full of grease to preclude wear of the yoke spindle bearing surfaces.

The four (4) hub assemblies were monitored by BHT Service Representatives during the test period. The overhaul of the first hub assembly to reach the TBO of 1200 hours showed maximum wear of any journal to be .0003. The bearing contact area exhibited a smooth burnished appearance. The remaining three (3) hub assemblies showed no adverse conditions.

BHT allowed by Service Letter, at the option of the operator, the opportunity to use the established procedure of lubricating main rotor hub assemblies with MIL-G-81322. BHT Service Department continued to monitor thirty (30) aircraft operating in Canada which had been modified. The Service Letter did not authorize the use of MIL-G-81322 in lieu of SAE 10W-30 Oil for the trunnion bearing, however seventeen (17) of the aircraft used MIL-G-81322 as the lubricant for the trunnion as well as the grip. The monitored aircraft, as of August 1975, had accumulated between 15,000 and 18,000 hours.

The location of the grease fitting at the inboard position on the grip was recognized as a possible problem. Improper purging of the grease could result in the outboard bearings receiving inadequate lubrication. During the fatigue testing of the 206L grip, one specimen was drilled and threaded to accept a grease fitting. The addition of the threaded hole and fitting had no affect on fatigue life. The hole is located 5.81 inches from the inboard end and eight (8) degrees down from the horizontal centerline through the grip. The location of the grease fitting in the outboard section of the grip cavity provides positive lubrication of inboard and outboard bearings.

A BHT Technical Bulletin was provided to commercial operators authorizing the modification of main rotor hubs to the greased lubrication in lieu of oil. A Technical Bulletin will be released to include MIL-G-81322 as the lubricant for the trunnion bearing.

Not one lubrication problem has been reported by operators who have modified the main rotor hub assembly. It is impossible to determine how many flight hours have been accumulated on greased hub assemblies but it is reasonable to advise the customer it is in excess of 36,000 hours.

The BHT P/N 206-010-105-3 retention strap was not previously addressed as no problems had been reported during the lubrication and seal tests. Subsequent to the greased main rotor hub test, BHT investigated the compatibility of the current urethane coating, used in the manufacture of retention straps, with SAE 10W-30 oil and MIL-G-81322 grease, during a four-hundred and thirty-two (432) hour test cycle the urethane coating had .45 percent weight loss with no gain when subjected to SAE 10W-30 oil. The same urethane was subjected to MIL-G-81322 grease. The test specimen lost .06 percent in weight during the first one-hundred forty-four (144) hours and gained .08 percent during the remaining two-hundred eighty-eight (288) hours. The test indicates SAE 10W-30 oil leaches one or more of the chemicals in the urethane coating. The new main rotor outboard retainer or seal should prevent grease from entering the cavity of the main rotor yoke and preclude deterioration of urethane retention strap when MIL-G-81322 grease is used in lieu of SAE 10W-30 oil.

CONCLUSION AND RECOMMENDATION

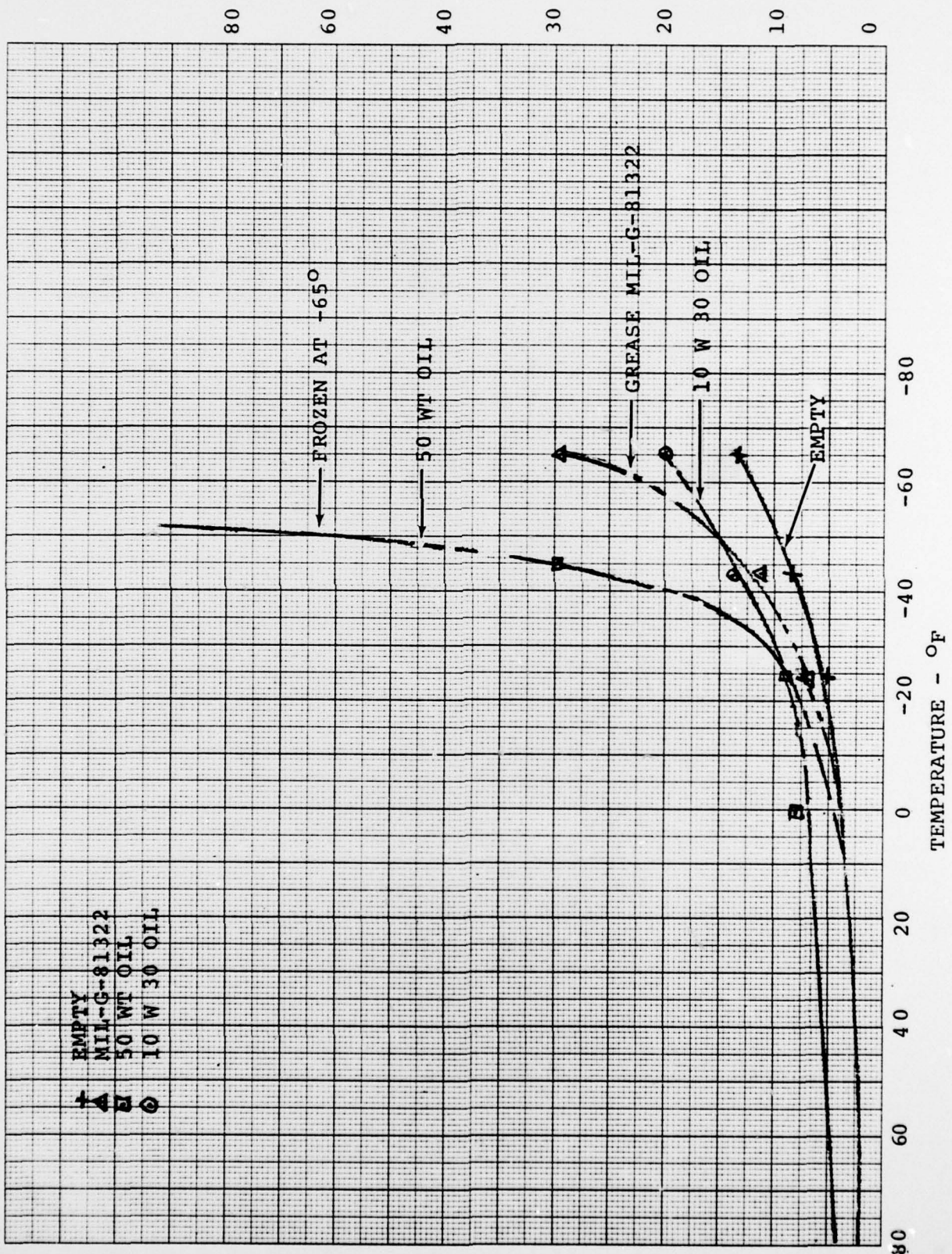
The contractor recommends that no additional testing be done and the facts established by the extensive testing accomplished by BHT and cooperating commercial operators be accepted as evidence of the successful solution to the leaking grip seals and trunnion lubrication.

APPENDIX

FLIGHT PROFILE FOR 1.5 HOURS FLIGHT TEST

- A. Touchdown and landings
 - 1. Three normal takeoffs
 - 2. Three maximum power takeoffs
- B. Nine turns at a bank angle of 45 degrees or greater
 - 1. Three turns at 70 knots
 - 2. Three turns at 80 knots
 - 3. Three turns at 100 knots
- C. Level flight at $N_{II} = 103\%$
 - 1. Nine minutes at maximum continuous power
 - 2. Nine minutes at 0.75 maximum continuous power
- D. Rolling pullouts at 1.5 to 1.75 load factor
 - 1. At 90 knots
 - 2. At 110 knots
- E. Nine minutes hover at 0 to 15 knots airspeed with
turns, IGE
- F. Autorotation
 - 1. Two power recoveries
 - 2. Touchdown and landing

BREAK AWAY FORCE AT PITCH HORN - LB



LUBRICANT AND CONDITION			
TEMP OF	10 W 30 MOTOR OIL	50 WT MOTOR OIL	MIL-G-81322 GREASE
0°	Flows	Flows	Soft
-25°	Flows	Soft - Flows When Stirred	Soft
-45°	Flows	Hard - Indents With Finger	Soft
-65°	Firm - Flows When Stirred	Frozen	Firm

PHYSICAL CONDITION OF SAMPLES PLACED
IN ENVIRONMENTAL CHAMBER WITH HUB
ASSEMBLY CONTAINING SAME LUBRICANT.

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